Systematic review of outcomes of combined proximal stent grafting with distal bare stenting for management of aortic dissection

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Objective: Available data on outcomes of combined proximal stent grafting with distal bare stenting for management of aortic dissection are limited. This is a systematic review of outcomes of this approach.

Methods: Studies involving combined proximal stent grafting with distal bare stenting for management of aortic dissection were systematically searched and reviewed.

Results: A total of 4 studies were included, with 108 patients treated for acute (n = 54) and chronic (n = 54) aortic dissection. Technical success rate was 95.3% (range, 84-100). The 30-day mortality was 2.7% (range, 0%-5%). Morbidity rate within 30 days was 51.8% (range, 0%-65%) and included stroke (2.7%), paraplegia (2.7%), retrograde dissection (1.8%), renal failure (14.8%), severe cardiopulmonary complications (5.5%), and bowel ischemia (0.9%). Incidence of type I endoleak was 9.2% (10/108). During follow-up, 5 patient deaths (4.6%) were related to aortic rupture or aortic repair. Reintervention rate was from 12.9%. Two cases of delayed retrograde type A dissection (1.9%) and 1 case of aortobronchial fistula (0.9%) were reported. Most common delayed complication was thoracic stent-graft migration (4.7%). Device failure rate was 9.2%. Favorable aortic remodeling was observed: studies reporting midterm follow-up of the true lumen demonstrated high rates of false-lumen regression and true-lumen expansion. At 12 months, complete false-lumen thrombosis was observed at the thoracic level in 70.4% and at the abdominal level in 13.5%.

Conclusions: Combined proximal stent grafting with distal bare stenting for management of aortic dissection appears to be a reasonable approach for type B aortic dissection, clearly improved true-lumen perfusion and diameter although failing to suppress false-lumen patency completely. Contemporary information on this approach is mainly provided by small series with a wide range of results. (J Thorac Cardiovasc Surg 2013;145:1431-8)

Acute dissection is the most common fatal aortic catastrophe, and the surgical treatment of Stanford type B acute aortic dissection remains a formidable challenge. The standard strategy for uncomplicated Stanford type B acute aortic dissection is medical management, with surgical intervention reserved for cases complicated by rupture, malperfusion, intractable pain, uncontrolled hypertension, and aneurysmal dilatation.

During the past decade, thoracic endovascular aortic repair (TEVAR) has been increasingly used to treat this condition when intervention has been necessary. The aim is to cover the entry tear to direct aortic flow preferentially into the true lumen. In one review, endovascular repair of acute complicated type B aortic dissection was associated with a lower 30-day mortality (2.8%) than that of open repair, and TEVAR was therefore regarded as the surgical therapy of choice.[1] Even if it is associated with a lower mortality than open surgery, however, stent grafting of complicated chronic type B aortic dissection remains controversial, despite thrombosing the false lumen adjacent to the stent-graft, because of concerns regarding durability.

Tsai and colleagues[2] showed that the natural course of false-lumen partial thrombosis in type B aortic dissection has a worse prognosis than that of a completely patent false lumen.[3] Complete exclusion of the false lumen, however, could improve the prognosis of this disease. To promote true-lumen expansion and false-lumen thrombosis, devices with bare metal stents that extend into the thoracoabdominal aorta have been used in an attempt to induce aortic remodeling. The ultimate aim of this technique is to prevent aortic aneurysmal evolution and rupture and to decrease the number of additional procedures required.

The aim of this study was to provide a systematic review of series that describe the outcomes of combined proximal stent grafting with distal bare stenting for the management of thoracic aortic dissection.

MATERIALS AND METHODS

Search Strategy

A literature search was undertaken to identify all published studies in the past 10 years reporting the combination of proximal stent grafting

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Abbreviation and Acronym
TEVAR = thoracic endovascular aortic repair

with distal bare stents for management of aortic dissection. Candidate studies in English were sought through a computerized search of MEDLINE (National Library of Medicine, Bethesda, Md) databases for the period of 1950 to September 2012. Key words entered in this search were "thoracic aorta" or "bare stent" "dissection," "endovascular," and "PETTICOAT." Additionally, manual evaluation of the reference lists of the retrieved articles and reviews on this area subject was undertaken.

Study Selection

Studies were considered for inclusion on the basis of the following criteria: (1) reporting on combined proximal stent grafting with distal bare stenting for management of aortic dissection, including at least 5 patients treated with this method, and reporting on clinical outcome. Studies containing duplicate data were excluded, and the studies from the same authors with the most recent or the best-documented material were used for analysis.

Data Extraction

Data were extracted regarding demographics, comorbidity, case selection (proportion of acute and chronic dissections, proportion of patients with symptoms, operative details, technical success, and early and midterm outcomes (endoleak, retrograde dissection, aortic rupture, stroke, paraparesis or paraplegia, renal failure, bowel ischemia, severe cardiopulmonary complications, 30-day and midterm mortalities, freedom from reintervention).

Severe morbidity was defined as mortality related to aortic repair or any of following nonfatal adverse events occurring within the postoperative hospital period: central nervous system complication (stroke or spinal cord ischemia with permanent deficit), type I endoleak, retrograde type I dissection, acute renal failure (attested by the need to initiate hemodialysis for the first time), cardiac failure, pulmonary distress syndrome or severe lung infection, bowel ischemia, aortobronchial fistula, and unplanned return to surgery.

Perioperative severe morbidity was defined as severe morbidity occurring within the first 30 postoperative days. Midterm morbidity was defined as severe morbidity occurring after the first 30 postoperative days.

RESULTS

Search Results

Four studies were integrated after a literature search and the exclusion of duplicated publications[3-6] (Table 1).

Case Selection

Patient demographic characteristics, presenting features, and comorbidities are shown in Tables 1 and 2. The mean age was 57.5 years, and 75.9% of the patients were male. The indication for endovascular repair (Table 3) was the presence of features of complicated aortic dissection (15 type A vs 93 type B; 54 acute vs 54 chronic). The most common comorbidities were hypertension (87.9%), hyperlipidemia (18%), renal failure (15.6%), and cardiac disease (12%).

The most commonly stated indication for intervention was malperfusion arising from branch vessel obstruction or true-lumen collapse (76/108, 70.3%). Other indications included refractory hypertension (41/108, 37.9%), refractory chest pain (36/108, 33.3%), rapid aortic enlargement (5 mm within 3 months) or transaortic diameter greater than 40 mm (35/108, 32.4%), and periaortic effusion or hematoma (10/108, 9.2%). Acute and chronic dissections could not be separated for the purpose of analysis.

Technical Success (Tables 4 and 5)

The Cook Zenith dissection device (Cook Medical Inc, Bloomington, Ind) was the most common deployed graft (96/108, 88.8%). A median of 1.27 stent-grafts (range, 1-3) and 1.27 bare stents (range, 1-3) were used per patient. The technical success rate was 95.3% (range, 84%-100%), with a median operative duration of 141 minutes (range, 40-397 minutes). Supra-aortic branch revascularization was performed in 23.1% of the patients (25/108). Adjunct endovascular procedures were required in 32 patients (29.6%). One patient (0.9%) underwent conversion to open surgery because a bare metal strut became lodged in the distal aorta.

Perioperative Outcomes (Table 6)

Perioperative outcomes were those occurring within the first 30 postoperative days. The overall 30-day mortality was 2.7% (3/108). The early morbidity rate was 51.8% (range, 0%-65%). Acute renal failure was the most common early complication (14.8%, 16/108), with 6 patients in this group requiring dialysis. In studies that reported endoleaks according to subtype, the global incidence of endoleak was 12% (13/108); type I incidence was 5.5% (6/108) and type II was 6.4% (7/108). The incidence of early

TABLE 1. Case selection

						Indication			
	Study period	Study type	N	Age* (y)	Male	Type A	Type B	Acute	Chronic
Nienaber et al[6]	—	Retrospective cohort	12	58.7 ± 10	83%	16.6%	83.4%	0%	100%
Hofferberth et al[4]	2003-2010	Retrospective cohort	31	57.8 ± 12.5	71%	41.9%	58.1%	81%	19%
Lombardi et al[3]	2007-2009	Prospective cohort	40	58 ± 11	70%	0%	100%	60%	40%
Melissano et al[5]	2005-2011	Retrospective cohort	25	56 ± 12	88%	0%	100%	20%	80%

All data are percentages of patients except as marked. *Mean ± SD.

TABLE 2. Case selection: Patient comorbidities

	HTA	Diabetes	Smoking	Hyperlipidemia	Cardiac disease	Chronic obstructive pulmonary disease	Renal failure	ASA class I	ASA class II	ASA class III	ASA class IV
Nienaber et al[6]	100%	—	—	16.6%	16.6%	—	50%	0%	0%	91.6%	8.4%
Hofferberth et al[4]	74.1%	9.6%	29%	22.6%	16.1%	—	—	—	—	—	—
Lombardi et al[3]	92.5%	7.5%	58.3%	7.5%	10.4%	2.6%	5%	—	—	—	—
Melissano et al[5]	92%	12%	52%	32%	8%	0%	15%	0%	32%	52%	16%

All data are percentages of patients. *ASA*, American Society of Anesthesiologists; *HTA*, hypertension.

retrograde dissection was 1.8% (2/108), and periprocedural aortic rupture occurred in 1.8% (2/108). The incidence of neurologic complications was 5.4% (6/108); of these complications, equal numbers were stroke and paraplegia or paraparesis. The early reintervention rate was 4.6%, and reintervention was required for renal artery occlusion, bowel ischemia, type II endoleak, and bare-stent misdeployment.

Midterm Outcomes (Table 7)

Midterm outcomes were defined as those occurring after 30 days. The all-cause mortality was 3.8% (4/105). There were 2 cases of delayed retrograde type A dissection (1.9%) and 1 case of aortobronchial fistula (0.9%). The most common delayed complication was stent-graft migration (5/105, 4.7%). The incidence of type I endoleak was 3.8% (4/105). No type II endoleaks were reported. Delayed aortic rupture was reported in 1.9% (2/105). Reintervention was necessary in 8.5% of patients (4%-13.3%) for complications such as retrograde type A dissection, type I endoleak, stent-graft migration, and aortobronchial fistula (Table 8).

Severe Morbidity Rate

Severe morbidity was defined as mortality related to aortic repair or any of the following nonfatal adverse events occurring within the postoperative hospital period: central nervous system complication (stroke or spinal cord ischemia with permanent deficit), type I endoleak, retrograde type I dissection, acute renal failure (attested by the need to initiate hemodialysis for the first time), cardiac failure, pulmonary distress syndrome or severe lung infection, bowel ischemia, aortobronchial fistula, and unplanned return to surgery. The overall severe morbidity rate was 33.3% (36/108). The perioperative severe morbidity rate was 17.6% (19/108). The midterm severe morbidity rate was 16.1% (17/105).

Device Performance

The rate of device failure was 9.2% (10/108). Component separation or device migration necessitating secondary interventions was reported in 5 patients. One case of focally ruptured Zenith dissection stent was reported, and 4 cases of a stent body misalignment of Cook Zenith dissection stent were reported.

Aortic Remodeling (Table 9)

Rates of complete false-lumen thrombosis ranged from 31.2% to 75% at the thoracic level and from 3.1% to 25.9% at the abdominal level. These data were not always complete, and the total number of patients for whom results were available was low. Studies reporting midterm follow-up of the true lumen demonstrated high rates of false-lumen regression and of true-lumen expansion (Table 9). Nienaber and colleagues[6] reported an increase in the true-lumen size and a concomitant decrease in the false-lumen size along the dissected aorta at 12 months, with a completely thrombosed thoracic false lumen observed in 75% of the patients. The fate of the false lumen at the abdominal aorta level was not reported.

Hofferberth and coworkers[4] reported increased true-lumen perfusion and diameter after a mean follow-up of 57.3 months, although perfusion of the abdominal or

TABLE 3. Case selection: Indication for aortic repair

	Branch vessel obstruction or compromise, or correction of true-lumen collapse	Periaortic effusion or hematoma	Resistant hypertension	Persistent pain or symptoms	Transaortic growth 5 mm within 3 mo (or transaortic diameter 40 mm)
Nienaber et al[6]	100%	0%	0%	0%	0%
Hofferberth et al[4]	100%	0%	0%	0%	0%
Lombardi et al[3]	67.5%	20%	65%	77.5%	52.5%
Melissano et al[5]	24%	8%	68%	20%	56%

All data are percentages of patients.

TABLE 4. Technical aspect

	Graft types	SGs per patient	Bare stents per patient	Adjunct procedures	Procedure time (min, mean ± SD)	Time from dissection to intervention (d, median and range)
Nienaber et al[6]	SG: Talent (66.6%), Excluder (16.6%), Valiant (8.3%), Zenith (8.3%); bare stent: Sinus (41.6%), Fortress (50%), Z stent (8.4%)	1.08 (1-2)	1.08 (1-2)	0% (0/12)	70 ± 15	—
Hofferberth et al[4]	Zenith Cook dissection	2.9 (1-5)		61.2% (19/31); SG (6/31): Iliac, renal, superior mesenteric arteries; ascending aorta open repair (13/31)	—	10.4 (1-1095)
Lombardi et al[3]	Zenith Cook dissection	1.27 (1-3)	1.37 (0-3)	37.5% (15/40); bare stent (9/40): Iliac, renal, superior mesenteric arteries; carotid–subclavian bypass (3/40); carotid–carotid bypass (3/40)	163 (40-397)	20 (0-78)
Melissano et al[5]	Zenith Cook dissection	1.32 (1-3)	1.28 (1-2)	96% (24/25); bare stent: Iliac, renal, superior mesenteric arteries (4/25); humeral thrombectomy (1/25); carotid-subclavian bypass (2/25); carotid–carotid bypass (17/25)	—	—

SG, Stent-graft; *SD*, standard deviation.

thoracic aortic false lumen was still observed in 74% of the patients.

Melissano and colleagues[5] noted a significant increase (98%) in true-lumen volumes at both the thoracic (115%) and abdominal segments (63%) at a mean follow-up of 57.3 months. At midterm follow-up (1 and 2 years), the overall aortic volume tended to decrease to preoperative values. The rate of false-lumen thrombosis was not reported. The abdominal segment, after initial true-lumen expansion, failed to remodel with stable true-lumen volume and had a tendency toward enlargement of the overall abdominal aortic volume as a result of abdominal false-lumen expansion.

Lombardi and colleagues[3] reported an increase in true-lumen size and a concomitant decrease in the false-lumen size in the dissected aorta at 12 months. A completely thrombosed thoracic false lumen was observed in 31% of their patients. Perfusion of the false lumen in thoracic and abdominal aortic segments was still present in 68.8% and 96.8% of their patients, respectively.

DISCUSSION

One of the drawbacks of stent grafting for complicated thoracic aortic dissection is that the thrombosis of the false lumen is frequently not complete, despite thrombosing the false lumen adjacent to the stent-graft during the procedure,

TABLE 5. Technical success and mortality

	Mean follow-up (mo)	Technical success rate	1-y survival	Overall aortic-related mortality	30-d aortic related mortality		>30-d aortic-related mortality	
					Rate	Etiology	Rate	Etiology
Nienaber et al[6]	—	100%	91.6%	8.3% (1/12)	0% (0/12)		8.3% (1/12)	Aortic rupture in mo 11
Hofferberth et al[4]	57.3	97%	93.7%	6.4% (2/31)	3.2% (1/31)	Stent-graft misdeployment: surgical conversion	3.3% (1/30)	
Lombardi et al[3]	—	100%	90%	7.9% (3/38)	5% (2/40)	Aortic rupture on d 11; sudden death on day 29	5% (2/38)	Aortic rupture on d 81
Melissano et al[5]	38 ± 17	84%	100%	0% (0/25)	0% (0/25)		0% (0/25)	

Data represent percentages of patients except as noted.

TABLE 6. Morbidity within 30 days

	Mean follow-up (mo)	Overall morbidity	30-d morbidity								
			Aortic rupture	Type I endoleak	Type II endoleak	Stroke	Paraparesis or paraplegia	Retrograde dissection	Cardiopulmonary	Renal failure	Bowel ischemia
Nienaber et al[6]	—	0% (0/12)	0%	0%	—	0%	0%	0%	0%	0%	0%
Hofferberth et al[4]	57.3	22.5% (7/31)	0% (0/31)	3.3% (1/31)	3.3% (1/31)	0%	0%	0%	3.3% (1/31)	12.9% (4/31)	0%
Lombardi et al[3]	—	65% (26/40)	5% (2/40)	2.5% (1/40)	7.5% (3/40)	7.5% (3/40)	5% (2/40)	5% (2/40)	12% (5/40)	17.5% (7/40)	2.5% (1/40)
Melissano et al[5]	38 ± 17	52% (13/25)	0% (0/25)	16% (4/25)	12% (3/25)	0%	4% (1/25)	0%	0%	20% (5/25)	0%

Data represent percentages of patients except as noted.

as a consequence of retrograde flow through the residual reentry tear or intimal fenestrations related to branch vessels.

This incomplete thrombosis exposes patients to increased risk of late aneurysmal degeneration and therefore aortic rupture. It has been reported by Tsai and colleagues[2] that the natural course of false-lumen partial thrombosis in type B aortic dissection has a worse prognosis than that of a completely patent false lumen. Complete exclusion of the false lumen should therefore clearly be the aim wherever possible.[2] To promote true-lumen expansion and false-lumen thrombosis, some authors have proposed the use of bare metal stents in the distal thoracoabdominal aorta. The PETTICOAT, (or Provisional Extension To Induce COmplete ATtachment) technique, was first reported in 2005 by Mossop and colleagues,[7] and in 2006 a series of 12 cases was reported.[6] This technique eliminates the entry tear and increases the true-lumen diameter in the distal aorta through a combination of stent grafting and bare metal stenting of the visceral and infrarenal segments.

To compare the results of proximal stent grafting with distal bare stenting against stent-graft placement without distal bare stenting for management of aortic dissection, a review of series reporting results for the latter technique in the management of complicated acute and chronic aortic dissection was performed (Tables 10-12).[8-27] The technical success rates reported for proximal stent grafting with distal bare stenting for management of aortic dissection were high (95.3%) and were similar to reported success rates of established endovascular techniques that used stent-grafts without distal bare stenting. The mean 30-day mortality after combined proximal stent grafting with distal bare stenting for acute and chronic aortic dissection in this study was 2.7%. This mortality is similar to rates recently reported by several authors describing results of TEVAR for acute and chronic dissection. Of especial note, however, was the rate of severe morbidity. The pooled rate of severe morbidity in this series was 33.3% (36/108). A meta-analysis describing the results of TEVAR for acute and chronic dissection reported a major complication rate of 11.1% ± 1.4%.[16] The most critical complications were related to retrograde extension of the dissection into the ascending aorta, neurologic complications, and aortic rupture. This more extensive approach was associated with slightly higher rates of dissection into the ascending aorta (3.7 vs 1.8%), neurologic complications (5.5 vs 3.1%), and aortic rupture (3.7 vs 2.5%); however, patients treated in this study represent a difficult patient subgroup, with 63.8% of the patients being seen with malperfusion or impending rupture. Eggebrecht and associates[8] reported

TABLE 7. Morbidity after 30 days

	Mean follow-up (mo)	Overall morbidity	>30-d morbidity							
			Aortic rupture	Type I endoleak	Type II endoleak	Stent-graft migration	Retrograde dissection	Cardiopulmonary	Renal failure	Aortobronchial fistula
Nienaber et al[6]	—	16.6% (2/12)	8.3% (1/12)	8.3% (1/12)	—	0%	0%	0%	0%	0%
Hofferberth et al[4]	57.3	16.6% (5/30)	3.3% (1/30)	3.3% (1/30)	—	3.3% (1/30)	3.3% (1/30)	0%	0%	3.3% (1/30)
Lombardi et al[3]	—	18.4% (7/38)	2.6% (1/38)	2.6% (1/38)	0%	5.2% (2/38)	2.6% (1/38)	2.6% (1/38)	2.6% (1/38)	0%
Melissano et al[5]	38 ± 17	12% (3/25)	0%	4% (1/25)	0%	8% (2/25)	0%	0%	0%	0%

Data represent percentages of patients except as noted.

TABLE 8. Secondary interventions

	Mean follow-up (mo)	<30 d		>30 d	
		Rate	Cause	Rate	Cause
Nienaber et al[6]	—	0% (0/12)		8.3% (1/12)	Type I endoleak
Hofferberth et al[4]	57.3	3.2% (1/31)	Bare stent misdeployment	13.3% (4/30)	Retrograde type A dissection, proximal stent-graft migration, aortobronchial fistula, type I endoleak
Lombardi et al[3]	—	7.5% (3/40)	Liver and gall bladder ischemia, renal artery stenting, renal artery stenting	7.9% (3/38)	Retrograde type A dissection, retrograde type A dissection and stent-graft migration, type I endoleak
Melissano et al[5]	38 ± 17	4% (1/25)	Type II endoleak	4% (1/25)	Stent-graft migration

the most favorable outcomes. Among 12 patients with a malperfusion syndrome, the overall severe morbidity was 16.6%: 1 patient died of an aortic rupture, and another received an additional stent-graft for a type I endoleak. This favorable result may be explained by the fact that this group advocated a staged approach to the procedure, allowing recovery from the acute insult of dissection and the initial procedure before evaluation of the need for extension of the graft with the bare metal components. Persistence of a distal malperfusion syndrome after proximal covered endograft placement is uncommon. Nienaber and colleagues[6] only reported this issue in 12 patients among a cohort of 100 patients (12%). This suggests that distal bare stenting could be planned only after evaluation after primary entry tear closure, rather than performed as a single-stage extensive repair of the thoracoabdominal aorta.

Achievement of a complete false-lumen thrombosis is challenging, and pursuing this goal compounds the risks of multiple procedures, cumulative radiation dose, and contrast exposure. By treating the entire thoracoabdominal aorta, combined proximal stent grafting with distal bare stenting, should limit the number of adjunct procedures required. The reintervention rate was 16.6% for severe complications, such as renal arterial occlusion, type I endoleak, retrograde dissection, aortic rupture, and aortobronchial fistula.

Hofferberth and coworkers[4] reported that adjunct bare metal stenting did not compromise branch vessel perfusion. This statement needs to be qualified. Adjunct intraoperative endovascular procedures to maintain patency of visceral or iliac arteries were required for 19 arteries. When compared with results of a recent study of TEVAR without distal bare stenting for management of complicated aortic dissection,[16] the rate of adjunct endovascular procedures was significantly lower (1% vs 17.6%) than after bare metal stent deployment in the distal thoracoabdominal aorta.

Device concerns have also been reported. Bertoglio and coworkers[28] reported the risk of stent misalignment, probably resulting from excessive manipulation of the delivery system or during catheter manipulation during adjunct or secondary procedures. Melissano and colleagues[5] reported 1 focally ruptured bare stent. Lombardi and colleagues[3] reported component separation or device migration necessitating secondary interventions in 2 patients. Hofferberth and coworkers[4] reported 1 case in which the bare stent became dislodged in the distal aorta, necessitating

TABLE 9. Aortic remodeling

		Thoracic aorta FL thrombosis		Abdominal aorta FL thrombosis	
	Change in TL-FL ratio	Complete	Partial	Complete	Partial
Nienaber et al[6]	At 1 y: before stenting TL:FL = 4/25 = 0.16, after stenting TL:FL = 23/11 = 2.1	75% (9/12)	8.3% (1/12)	—	—
Hofferberth et al[4]	At 1 y: before stenting TL expansion/FL = 84/332 = 0.25, after stenting TL:FL = 216/248 = 0.87	66.6% (18/27)	33.4% (9/27)	25.9% (7/27)	70.3% (19/27)
Melissano et al[5]	At 2 y: FL reduction = 65%; before stenting TL:FL = 84/332 = 0.25, after stenting TL:FL = 216/248 = 0.87	—	—	—	—
Lombardi et al[3]	At 1 y: TL increased ($P < .05$), FL decreased ($P < .05$)	31.2% (10/32)	68.8% (22/32)	3.1% (1/32)	81.3% (26/32)

Data represent percentages of patients except as noted. *FL*, False lumen; *TL*, true lumen.

TABLE 10. Endovascular stent-graft repair without distal bare stenting for management of acute and chronic complicated type B aortic dissection

First author	Year	n	Acute (n)	Technical success	Retrograde dissection	Stroke	Paraplegia	Renal failure	Adjunct distal reperfusion	Aortic rupture	30-d mortality
Eggebrecht[8] (meta-analysis)	2006	609	248	98%	1.9%	1.9%	0.8%	NA	NA	2.3%	5.3%
Dialetto[9]	2005	56	14	100%	4%	0%	0%	NA	0%	1.7%	10.7%
Nathanson[10]	2005	40	23	95%	NA	2.5%	2.5%	13%	0%	0%	2.5%
Sayer[11]	2008	78	38	100%	1.2%	0%	2.5%	NA	0%	3.8%	5.1%
Böckler[12]	2009	54	24	93%	3.7%	0%	0%	NA	0%	0%	11.1%
Kische[13]	2009	180	37	98.3%	1.8%	3.9%	2.8%	NA	2.7%	4.2%	5%
Younes[14]	2010	23	11	100%	0%	5.5%	5.5%	0%	0%	0%	5.5%
Parsa[15]	2010	55	22	100%	0%	0%	2%	1.8%	0%	0%	2%
Yang[16]	2012	61	33	100%	1.6%	1.6%	1.6%	1.6%	1.6%	6.5%	6.5%
Overall		1156	450 (38.9%)	98.3%	1.8%	1.9%	1.2%	NA	1%	2.5%	5.5%

Data represent percentages of patients except as noted. *NA*, Not available.

conversion to open surgery and leading to the death of the patient.

The combination of proximal stent grafting with distal bare stenting for management of aortic dissection clearly improved true-lumen perfusion and diameter; however, it apparently failed to suppress false-lumen patency completely. At 1-year, false-lumen patency was still present in 29.6% of the patients at the thoracic level and in 86.5% of the patients at the abdominal level. Data on patients for whom complete imaging was available beyond this period were limited. Yang and colleagues[16] studied aortic remodeling after TEVAR for acute and chronic dissection, and they reported a comparable rate of false-lumen patency of 19.4% at the thoracic level at 1 year.

This review has several limitations. Although it is the only review to date on combined proximal stent grafting with distal bare stenting for management of aortic dissection, the pooled results are weakened by the lack of standardization in reporting patients' specific data and end points. In addition, the data are insufficient for separate analyses of outcomes for acute or chronic dissections. Furthermore, we specifically focused the review on clinical outcome. Finally, some studies with small sample sizes were included, whereas a larger number of patients is needed for better identification of statistically significant differences.

CONCLUSIONS

In this analysis, the combination of proximal stent grafting with distal bare stenting for the management of aortic dissection clearly improved true-lumen perfusion and diameter; however, it failed to suppress false-lumen patency completely and carried nontrivial risks of severe morbidity. Distal bare stenting could be proposed as a second stage to treat cases of persistent distal malperfusion syndrome after careful evaluation of the immediate results of primary entry tear closure, rather than as part of an extensive single-stage repair of the thoracoabdominal aorta. Nevertheless, no reliable long-term data exist to assess the durability of combined proximal stent grafting with distal bare stenting for the management of aortic dissection, and contemporary conclusions spring mainly from relatively small case series or retrospective studies. Furthermore, results of management of acute and chronic dissection should be reported separately to allow a more accurate analysis. Prospective trials of combined proximal stent grafting with distal bare stenting versus stent grafting

TABLE 11. Endovascular stent-graft repair without distal bare stenting for management of acute complicated type B aortic dissection

	Year	N	Technical success	Retrograde dissection	Stroke	Paraplegia	Renal failure	Adjunct distal reperfusion	Aortic rupture	30-d mortality
Conrad[17]	2009	33	100	9	3	12	0	0	6	12
Khoynezhad[18]	2009	28	90	3.5	3.3	0	10	3.5	0	11
Shu[19]	2010	45	100	0	0	0	4.4	0	0	4.4
White[20]	2011	85	100	0	9.4	9.4	9.4	4.7	14	10.6
Qin[21]	2012	124	100	24	0.8	0.8	NA	13.7	0	0
Ehrlich[22]	2013	29	100	3.4	6.8	0	0	20	6.8	17
Overall	28	450	450	450	450	450	450	450	450	450

Data represent percentages of patients except as noted. *NA*, Not available.

TABLE 12. Endovascular stent-graft repair without distal bare stenting for management of chronic complicated type B aortic dissection

	Year	N	Technical success	Retrograde dissection	Stroke	Paraplegia	Renal failure	Adjunct distal reperfusion	Aortic rupture	30-d mortality
Kim[23]	2009	72	97.2%	0%	0%	0%	1.4%	0%	0%	0%
Xu[24]	2010	84	91.7%	0%	0%	0%	4.8%	0%	4.8%	1.2%
Czerny[25]	2010	14	85.7%	0%	0%	0%	0%	0%	0%	0%
Kang[26]	2011	76	96%	3.9%	1.3%	0%	0%	0%	0%	5%
Andacheh[27]	2012	73	99%	5.4%	1%	1%	0%	0%	2.7%	14%
Total		319	95.8%	2.1%	1.8%	0.3%	1.5%	0%	1.8%	4.7%

Data represent percentages of patients except as noted.

without distal bare stenting are needed to assess outcomes of this extensive approach.

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